SPoRT Trial Evaluation of Global Precipitation Measurement (GPM) Mission Level 2 Rain Rate and Level 3 IMERG Products

MATT SMITH, ANITA LEROY, BRAD ZAVODSKY, KEVIN FUELL
NASA/Short-term Prediction Research and Transition (SPoRT), Huntsville, Alabama

1. Introduction

Forecasters at National Weather Service (NWS) Weather Forecast Offices (WFOs) face challenges related to ground-based radar voids in coastal areas, mountain regions, and near international borders. One way to approach addressing this forecast challenge is through the use of satellite-based precipitation measurements, such as those from the Global Precipitation Measurement (GPM) mission, a joint mission with NASA and the Japanese Aerospace Exploration Agency (JAXA). GPM officially began with the launch of its Core Observatory platform in February 2014. The mission, however, includes data from an international constellation of 12 satellites with similar passive microwave instruments (and more to be launched in the coming years). The GPM Microwave Imager (GMI) and its Dual-frequency Precipitation Radar (DPR) aboard the Core Observatory are being used to intercalibrate GPM products, to generate opportunities for unprecedented temporal resolution from polar-orbiting precipitation sensors.

Through discussions with NASA/SPoRT's NWS partners in the southwestern U.S. and Alaska, it was determined that swath-based rain rates (RR) from the GPM Level 2A Goddard PROFiling (2A-GPROF) algorithm may be valuable for situational awareness and filling radar voids, and gridded Level 3 products from the Integrated Multi-satellitE Retrievals for GPM (IMERG) may be useful for hydrologic applications. Specifically, the *calibrated precipitation* variable was used in IMERG products. The 2A-GPROF rain rates are available 20-35 times per day at a spatial resolution of approximately 15-30 km. The IMERG product is calculated on a 0.1˚ grid, available every 30 minutes. The "Early Run" of IMERG, which currently has a latency of ~6 hours, was used in this evaluation due to large latencies of the "Late" and "Final Run" versions of IMERG (~1.5 – 30 days, respectively). Cumulative IMERG precipitation products of 1, 3, 6, 12, and 24 hours were created by SPoRT and also made available to both forecasters and hydrologist.

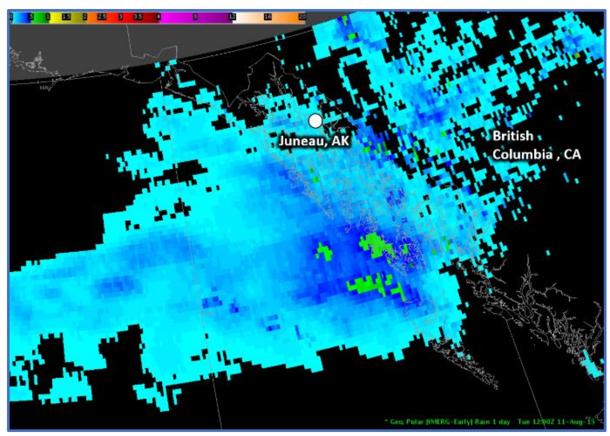

Figure 1. GPM IMERG 24-hr precipitation accumulation for southeast Alaska area ending at 1200 UTC 11 August 2017. Precipitation shown in scaled color bar and borders/shoreline by a light gray line.

As a GPM Early Adopter, SPoRT was able to obtain initial access to 2A-GPROF and IMERG in April 2015 to begin the process of reformatting the data for display in the NWS Advanced Interactive Weather Processing System (AWIPS) starting. Forecasters were asked to compare the GPM products to the NESDIS Quantitative Precipitation Estimate

(QPE; previously evaluated in 2013) for both instantaneous RR and the same cumulative precipitation amounts mentioned above.

Two regions with widely differing precipitation regimes and forecast challenges were selected for participation in this trial. The evaluation period was from 15 July – 30 August 2015. The NWS Juneau (AJK) and Anchorage (AFC) WFOs evaluated the operational impact of using GPM products in data- and/or radar-void areas (e.g. offshore/marine, AK interior, beam-blocked regions) to analyze areas of precipitation.

Much of the precipitation that falls in southern/southeast Alaska comes from over the Gulf of Alaska; so the use of satellite-based precipitation observations helps forecasters to anticipate where, when, and how much precipitation may occur in these regions and downstream. The NWS Albuquerque (ABQ) and Tucson (TWC) WFOs have a need for precipitation monitoring in radar-void regions such as over northern Mexico and in coverage gaps (beam blockage or overshooting) in the southwest U.S. During the summer months, monsoonal conditions set up in the southwest U.S. and transport moisture northward from Mexico, where there is no quality radar coverage. Application of GPM precipitation products was examined to add value in these from GPM may add value here.

For the challenge of analyzing the output of QPE methods and/or hydrologic models, the Southeast (Atlanta, GA), Colorado Basin (Salt Lake City, UT), and Alaska/Pacific (Anchorage, AK) NWS River Forecast Centers (RFC) were provided with IMERG observations for comparison. User feedback was gathered to help identify any specific limitations with operational use of IMERG and to communicate the potential for more sustained operational utility within the user's QPE analysis or modeling framework in the future.

2. User Feedback and Product Impacts

During the trial period SPoRT collaborated with forecasters by answering questions and gathering comments via phone or email. Forecasters were also provided with a brief web-based form to rate the impact of each product. In total, there were 21 online feedback forms submitted. An example of the user feedback regarding IMERG impacts is shown in Fig. 1. A more thorough overview of these results was presented at the 30th Conference on Hydrology (96th AMS, New Orleans, LA 2016 Jan 14).

a. GPM Level-2 Rain Rate

Forecasters at the Alaska WFOs were the primary users of the 2A-GPROF swath data (Fig.2). The product was deemed by forecasters as most useful for identifying rainfall location and timing.

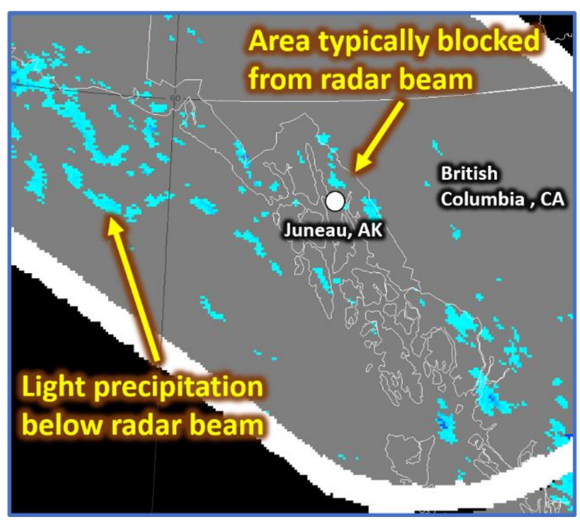

Figure 2. GPM Microwave Imager (GMI) level-2 rain rate swath passing over the Juneau, Alaska area at 0801 UTC 13 July 2017. Precipitation shown in shades of aqua and blue and borders/shoreline by a light gray line.

The shorter latency of the 2A-GROF made this product useful for both WFO and RFC applications. Confidence in 2A-GROF rainfall rate magnitudes was generally low due to mixed over- and under-estimations when compared to local gauge results. When compared to other precipitation data observations, the 2A-GPROF had instances of missing some light and moderate rain events, but overall had good agreement with precipitation occurrences.

b. GPM Level-3 Rain Rate (IMERG)

The IMERG RR proved to be the most popular product evaluated. It was useful in areas where radar coverage was missing or lacking. It also provided useful timing and coverage information. Due to the IMERG latency of 6+ hours, the product was most impactful in a post-event mode. As with 2A-GPROF, there were a mix of over-, under, and accurate estimations of RR magnitudes compared to in-situ observations. One, frequent limitation noted by the forecasters was light rainfall being missed by IMERG RR, particularly over southeastern Alaska. For example, AJK WFO feedback on 26 July 2015 indicated that between 1500-1600 UTC, IMERG did not pick up on Yakutat rain, and it still had the precip off to the west. At this time the Yakutat airport was reporting light rain of 0.01-0.03” per hour. On the other end of the spectrum, heavy precipitation (especially related to convection) was overestimated.

As an operational decision-making product, the IMERG RR impact was mixed, with 34% of the user feedback deeming the product as having “some”, “small”, or “large” impact on operations for a given event (Fig. 3). This was not particularly surprising given the latency of the product and access to the 2A-GPROF with much small latency. However, there were two specific instances where the IMERG RR was used in a post-event report. The first instance was from an event that resulted in a local canyon flash flood and subsequent fatality within ABQ WFO area. The cumulative IMERG products were used to assess the QPE amount over a period of time in this radar-void area. The second example was from the AJK WFO, where IMERG RR was used following a fatal landslide in the Sitka, Alaska area.

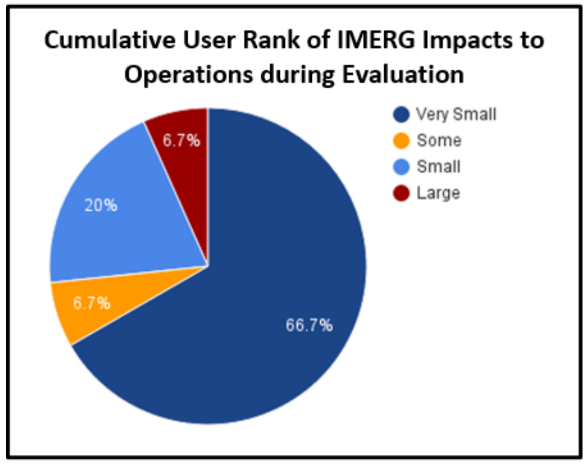

Figure 3. Forecaster feedback on the operational impact of IMERG rain rate/accumulation products.

For the landslide case, AJK WFO Service Hydrologist found that the IMERG product did an excellent job of capturing the localized nature of the extreme precipitation event that caused the landslide (Fig. 4).

Figure 4. Forecaster feedback on the operational impact of IMERG rain rate/accumulation products.

Forecasters expressed confidence in the IMERG location of the heaviest rains, but they were less sure in the IMERG quantitative values.

3. Conclusions and Recommendations

The smaller latency of the 2A-GROF RR made it useful in WFO operations, in addition to RFC applications. The product was somewhat more trusted than IMERG RR for analysis of precipitation locations and movement due to shorter latency and less complicated processing. There are no specific recommendations on improvements needed for GPM 2A-GPROF RR based on user feedback.

The GPM Level-3 IMERG RR product proved useful for post-event weather and hydrologic applications according to user feedback. In addition to submitted feedback or application examples, the operational value of the IMERG RR can be inferred from the desire by the forecasters and hydrologists to have continued access after the trial evaluation. SPoRT continued to make both of these products available within the AWIPS system and plans to continue "early adopter" work with the GPM science team to transition improved versions of the 2A-GPROF and IMERG RR products.

Specific recommendations for IMERG RR:

- Reduce latency to make the product more operationally viable. GPM's 4-hour latency goal for the Early Run would be useful to RFCs or perhaps even the NWS Weather Prediction Center. Current IMERG latency (~6 hours) makes the product mostly valuable in a post-event mode.
- Improve the detection efficiency of low and high rainfall rates.
- Extend the IMERG domain poleward of 60^{o}N. Forecasters in Alaska are very eager to evaluate and apply this type of data in their radar- and data-void regions.